UNCLA

To be scanned

RR00126

37110000

June 1967

DATA

HISTORY OF THE EARLY THERMONUCLEAR WEAPONS

Mks 14, 15, 16, 17, 24 and 29

SC-M-67-661

Information Research Division, 3434

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW	
1ST REVIEW-DATE: 3-15-96	DETERMINATION [CIRCLE NUMBER(S)]
AUTHORITY: ☐AOC ☒ADC ☐ADD	1. CLASSIFICATION RETAINED
NAME: Jerome C. [illegible]	2. CLASSIFICATION CHANGED TO:
2ND REVIEW-DATE: 4-3-96	3. CONTAINS NO DOE CLASSIFIED INFO
AUTHORITY: ADD	4. COORDINATE WITH: DOD
NAME: DC [illegible]	5. CLASSIFICATION CANCELLED
	6. CLASSIFIED INFO BRACKETED
	7. OTHER (SPECIFY):

RESTRICTED DATA

This document contains restricted data as defined in the Atomic Energy Act of 1954. Its transmittal or the disclosure of its contents in any manner to an unauthorized person in prohibited.

THIS DOCUMENT CONSISTS OF 59 PAGES,

NO. 3 OF 5 COPIES, SERIES A.

UNCLASSIFIED

~~SECRET~~

ATT 3

UNCLASSIFIED ~~SECRET~~

UNIQUE DOCUMENT #SAC200087110000

June 1967

RS 3434/10
AEC ATOMIC WEAPON DATA
Sigma 1

HISTORY OF THE EARLY THERMONUCLEAR WEAPONS

Mks 14, 15, 16, 17, 24 and 29

SC-M-67-661

Information Research Division, 3434

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW	
1ST REVIEW-DATE: 3-15-96	DETERMINATION (CIRCLE NUMBER(S))
AUTHORITY: ☐AOC ☒ADC ☐ADD	1. CLASSIFICATION RETAINED
NAME: [signature]	2. CLASSIFICATION CHANGED TO:
2ND REVIEW-DATE: 4-3-96	3. CONTAINS NO DOE CLASSIFIED INFO
AUTHORITY: ADD	4. COORDINATE WITH: DOD
NAME: [signature]	5. CLASSIFICATION CANCELLED
	6. CLASSIFIED INFO BRACKETED
	7. OTHER (SPECIFY):

RESTRICTED DATA

This document contains restricted data as defined in the Atomic Energy Act of 1954. Its transmittal or the disclosure of its contents in any manner to an unauthorized person in prohibited.

THIS DOCUMENT CONSISTS OF 59 PAGES,

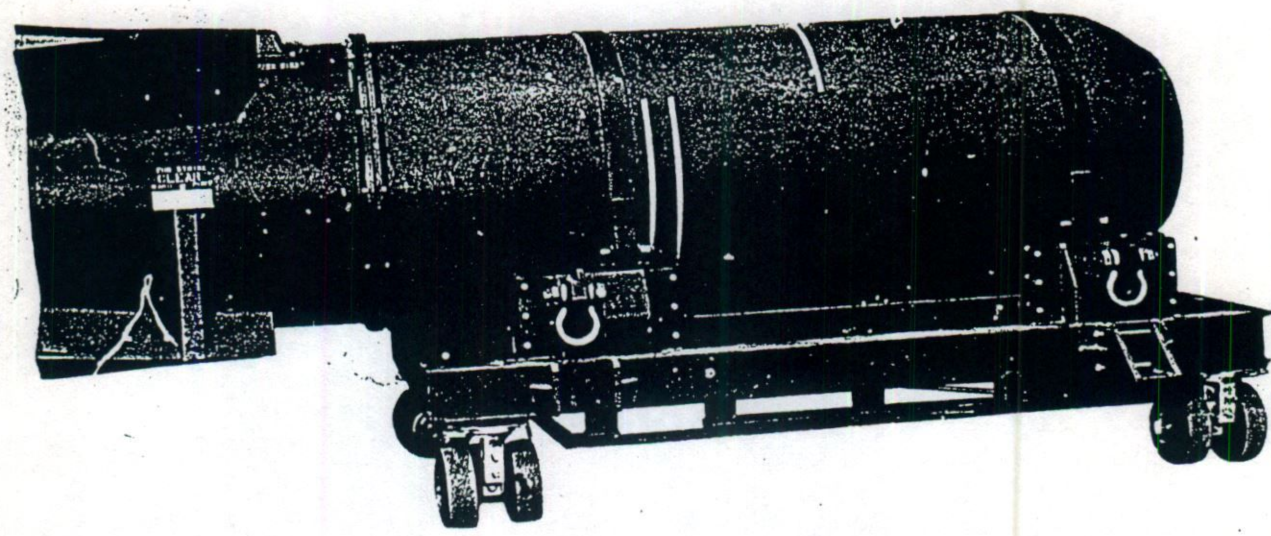
NO. 3 OF 5 COPIES, SERIES A.

UNCLASSIFIED

~~SECRET~~

ATT 3

b(3)
DoE



Weapon on H-508

UNCLASSIFIED

~~SECRET~~ RS 3434/10

S[redacted]

B(3)
DoE

UNCLASSIFIED

RS 3434/10

[redacted]

b(3)
DOE

[redacted]

UNCLASSIFIED

[redacted]

[redacted]

RS 3434/10

b(3)
DoE

[redacted]

UNCLASSIFIED

[redacted]

~~SECRET~~

RS 3434/10

Timetable of Early Thermonuclear Weapons Events

Mk 14

Late 1920's	Discovery made that stellar energy is thermonuclear in character.
Early 1942	Discussion concerning theoretical possibility of starting a thermonuclear reaction with a fission bomb.
7/42	Basic nuclear studies of lightweight elements performed. [redacted] Extensive work deferred due to press of effort on fission devices.
Postwar	Effort on thermonuclear studies deferred.
1947	[redacted]
8/49	Russian atomic explosion announced.
1/31/50	President Truman directs that effort be continued on thermonuclear designs.
5/8/51	George shot of Operation Greenhouse demonstrates that deuterium and tritium can be made to fuse successfully.
6/19/51	Conference on thermonuclear theory held at the Institute for Advanced Study. Edward Teller proposes that results of Shot George were obtained by radiation implosion.
5/22/52	Sandia and Los Alamos propose guidelines for design of thermonuclear weapon to be called the TX-14; emergency-capability committee established.
6/13/52	Joint Chiefs of Staff establish requirement for thermonuclear weapons with yields of at least 1 megaton.

b(3) DOE

b(3) DOE

UNCLASSIFIED

~~SECRET~~

9/15/52 Procurement for TX-14 program authorized.

[redacted] b(3) DoE

10/26/53 TX-Theta Committee formed, and holds initial meeting.

2/54 Emergency-capability TX-14's produced.

10/54 TX-14 Bombs retired.

Mk 15

[redacted] b(3) DoE

10/12/53 Los Alamos notifies Division of Military Application that TX-15 will be stockpiled by September 1955.

[redacted] b(3) DoE

11/13/53 Proposed military characteristics for TX-15 released by Field Command. Both bomb and warhead planned for production.

[redacted] b(3) DoE

[redacted]

~~SECRET~~ RS 3434/10

3/26/54 TX-Theta Committee decides to restrict TX-15 design to bomb application.

[redacted]

b(3) DOE

5/21/54 Sandia reports difficulties in designing contact fuze for TX-15.

6/30/54 Special Weapons Development Board reviews proposed ordnance characteristics for TX-15.

10/54 Mk 15 Mod 0 Bomb design released.

1/6/55 TX-Theta and TX-N Committees discuss possibility of providing a Mk 15 Warhead.

[redacted]

b(3) DOE

5/3/55 Secretary for Defense requests additional Mk 15 design programs.

12/2/55 Division of Military Application redesignates the Mk 15 modification program of weight reduction, contact fuze, and thermal battery as the TX-39. The Mk 15 Mod 1 was to eliminate the weight-reduction portion of the program, but the Mk 15 Mod 1 was later canceled.

3/57 Mk 15 Mod 2, with safing device and nuclear improvements, enters stockpile.

<u>TX-29</u>

Early 1954 Feasibility study of modified Mk 15 design for use with NAVAHO missile authorized.

3/16/55 Division of Military Application requests that TX-29 program be canceled in favor of the Mk 15.

8/28/55 Division of Military Application cancels TX-29 design.

TX-16

[redacted]

b(3) DOE

b(3) DOE

1/53 TX-16 Panel appointed to study weapon logistics.

12/7/53 TX-16 initially tested in drop.

[redacted]

b(3) DOE

4/13/54 Drops tests of TX-16 completed. Good ballistic results secured.

4/15/54 Sandia releases nonnuclear portion of the TX-16 design.

Mk 17/24

[redacted]

b(3) DOE

b(3)
DoE

5/21/54	TX-Theta Committee suggests improvements to the Mod 0.
5/54	Emergency capability TX-17/24 Bombs stockpiled.
11/2/54	TX-17 parachute drop tests started.
11/54	All TX-17/24 emergency-capability units modernized to Mod 0 status.
12/54	Mk 17/24 Mod 1 design released, including inflight insertion mechanism for increased safety, fin of composite metal and plastic, and nuclear improvements.
3/55	Mk 17/24 Mod 1 Bombs enter stockpile.
6/1/55	Mk 17 Mod 2 design released, incorporating contact fuze.
9/55	All Mk 17/24 Mod 0 Bombs converted to Mk 17/24 Mod 1.
8/56	About 25 percent of Mk 17 stockpile converted to Mod 2. Mk 24 Mod 2 program canceled.
10/56	All Mk 24's retired in favor of Mk 36.
8/57	Mk 17 Bombs retired in favor of Mk 36.

History of the Early Thermonuclear Weapons

Mk 14

The possibility of producing a terrestrial thermonuclear reaction had been discussed by scientists ever since the discovery in the late 1920's that stellar energy was thermonuclear in character. As was the situation in ordinary thermal combustion, however, there had to be an igniting "match" or some means of starting the process, and prior to 1942 there was no imaginable device that could be used to start this reaction.[1]

In early 1942, some months before the formation of the Manhattan Engineer District, a group of theoreticians was formed at the University of California under the leadership of J. Robert Oppenheimer, and assigned the task of compiling fission theory.[2] As the possibility of creating an atomic bomb emerged, it became evident that the bomb itself might develop stellar temperatures and provide an igniting "match" for a thermonuclear reaction. It was theorized that the energy produced in the fission process would not be able to overcome the barrier between the nuclei of heavy-weight elements, but that this energy might be more than enough to overcome the barrier between the nuclei of light-weight elements.

This was breathtaking, and in July 1942 Oppenheimer passed this information on to Arthur H. Compton of the University of Chicago, who had requested the fission study. Arrangements were subsequently made for basic nuclear studies of light elements, using cyclotrons at Harvard and the University of Michigan.[3]

It was known that the lightest element, which contained a nucleus and an orbiting electron, could exist in three forms or isotopes; hydrogen, deuterium and tritium. Hydrogen had a nucleus containing one proton; deuterium had a nucleus of one proton and one neutron; and tritium had a nucleus of one proton and two neutrons. Hydrogen, of course, was plentifully available. In nature, deuterium existed in heavy water, which was present to a very small percentage in ordinary water. Tritium was an artificial element that could be manmade in an atomic pile at high expense, using materials which were needed for production of fission bombs.

It was found that two hydrogen nuclei would not combine. Two deuterium nuclei would, under proper conditions, fuse to produce either helium or tritium and, in this process, emit energy. Deuterium and tritium would fuse to produce an isotope of helium and also emit energy, and this process would occur more readily than the fusion of two deuterium nuclei. However, since deuterium was relatively cheap and tritium expensive, it was more desirable to use the deuterium-plus-deuterium fusion process, although this was harder to start.[4]

It was hoped that the energy of an atomic bomb would heat deuterium to the temperature where the deuterium nuclei would fuse.

b(:
Do

The hydrogen bomb thus acquired the nickname of "Super." Further study showed that the temperature created by detonation of a fission bomb was high enough to trigger the fusion process, but that this temperature would not exist for a long enough time to ignite a mass of gaseous deuterium. Some attention was given to liquifying deuterium, to increase its concentration, and a small cryogenics plant was established at the Los Alamos Laboratory during the war. Experimental quantities of tritium were produced at Oak Ridge by irradiation of lithium and used for study. However, the practical difficulties were found to be enormous, and work on the hydrogen bomb tended to be overshadowed by the effort involved in the fission weapon.

Fundamental experiments were continued after the end of the war, although the heavy loss of Manhattan Engineer District scientific personnel in late 1945 and

throughout 1946 was a hampering factor. Additionally, it was felt by many nuclear physicists that the development of a hydrogen bomb was inherently evil, and would encourage warfare between nations.

[redacted]

b(3)
DoE

Meanwhile, other agencies were also advocating development of a thermonuclear weapon. When the Office of Scientific Research and Development was abolished at the end of World War II, concern was felt that there would be no organization to carry on research and development work for new military equipment and weapons. This led to a decision by the Secretaries of War and Navy to create a Joint Research and Development Board June 6, 1946. This Board established several committees, one called the Committee on Atomic Energy. This latter group compiled a list of long-range objectives for the military atomic-energy program which was released August 18, 1948; and, a month later, the Los Alamos Scientific Laboratory forwarded its plans for 1949 to the Atomic Energy Commission. Both reports advocated continued research into the theory of the Super weapon.[6]

The Committee on Atomic Energy report was apparently ignored and the Los Alamos plan rejected by the Military Liaison Committee in favor of emphasis on smaller devices such as the Mk 5. This trend was reinforced by the Berlin Blockade and the possibility of an outbreak of open hostilities, which would require that every bit of fissionable material be used in the weapon stockpile. Meanwhile, lack of a fast computer slowed investigation of fusion theory.

Thus, in 1949, the Super represented pure fantasy. Such was the situation when United States President Harry S. Truman was informed that an atomic explosion had occurred somewhere in Siberia in late August 1949. On January 31, 1950, after having received an almost equal division of opinion between experts on whether the

hydrogen bomb should or should not be developed, the President directed the Atomic Energy Commission to continue its work on all forms of atomic weapons, including the so-called hydrogen or Super bomb. Work on Super was accordingly accelerated, only to be retarded again in mid-1950 when the outbreak of the Korean War re-emphasized the need for small nuclear devices.

The Air Force made early plans to carry and deliver large and heavy hydrogen bombs and, in 1950, established two projects, Brass Ring and Caucasian. Brass Ring envisioned carriage of the weapon in an unmanned drone B-47, which would be guided to a target by a mother ship and destroyed in the detonation. This project was given considerable support, due to uncertainty concerning the possible yield of a hydrogen bomb, then estimated to lie between 10 and 40 megatons.

b(3) DOE

[redacted]

b

This possibility was discussed at a conclave of scientists and AEC representatives June 19, 1951, and it was concluded by the attendees that a practical thermonuclear weapon was achievable, using radiation energy as a compressing force.

Due to some personal differences of opinion, Teller proposed the creation of a new physics laboratory to develop thermonuclear devices. He was supported in this stand by the Air Force, which offered to provide a suitable laboratory. Subsequently, the

AEC established a laboratory at Livermore, California, under the administration of the University of California. The contributions of the University of California Radiation Laboratory to the early development of thermonuclear weapons were somewhat meager, except that the existence of the laboratory helped to encourage the over-all program.

[redacted]

b(3
Dc

The computational work involved in analyzing the thermonuclear process was a colossal task, and could not have been accomplished without the great advances in computing equipment that took place in the late 1940's and early 1950's. The IBM 601 was considered quite a machine in 1945, but it was far surpassed by the Maniac, designed at the Institute for Advanced Study, Princeton, New Jersey, and which became available in 1952. A problem that would require 3 months work by the 601 could be solved in 2 days by the Maniac. It is of record that, in the course of running a thermonuclear problem on the Princeton Maniac in 1953, the number of basic arithmetical computations performed was of the same order of magnitude as the total number of similar operations performed at Los Alamos (excluding those done on the Los Alamos Maniac) in the entire 10 years of operation of the Laboratory.

The first task assigned to the Los Alamos Maniac was to perform more exact and extensive calculations of the thermonuclear process. The theory of radiation implosion was refined and reinterpreted, and the flow of radiation pressure along channels between the fission and fusion components of the bomb was determined. [redacted]

b(
D

Sandia and Los Alamos forwarded a joint letter to the Division of Military Application May 22, 1952, proposing that the TX-14 be designed with the following guidelines:

1. Maximization of yield to the point where escape of a manned transporting bomber was impossible (the use of an unmanned drone had meanwhile been discarded), or production of the largest yield possible in the size allowed.

2. Diameter not to exceed 64 inches; length, about 20 feet; and weight, about 50,000 pounds. (This made the TX-14 comparable in length and weight to the World War II Block Buster bomb which was 27 feet long and weighed 44,000 pounds).

3. Bomb to be capable of withstanding forces involved in careful handling, aircraft loading and carrying, and free or retarded fall.

4. Bomb to have a capability for air-burst operation only.

[redacted] b(3 DOE The term "emergency capability" was defined to mean that there would be no factors that would prevent carriage of the TX-14 in manned aircraft. No "gold-plated" engineering would be done, operational suitability tests would not be conducted, information on reliability would be lacking, no inflight insertion device would be provided, and assembly and use would require the services of trained scientists and engineers. These TX-14 emergency-capability devices would thus be in a state corresponding to the Little Boy and Fat Man bombs at the time of their use in World War II.

Los Alamos was assigned overall responsibility for the TX-14, and Sandia would provide the ordnance engineering. [redacted] b(3 DOE

The Division of Military Application forwarded this proposal to the Military Liaison Committee, which replied, June 13, 1952, that the Joint Chiefs of Staff

had established a military requirement for the development of thermonuclear weapons with yields of 1 megaton and over, requesting that these weapons be compatible in size, shape and weight with delivery systems that would be available in 1954. Production facilities for thermonuclear materials would be developed immediately. It was felt that any prior production of a deliverable thermonuclear weapon by the Soviet Union would reduce the existing American lead in weaponry, and that such a shift in balance might well cause a change in Soviet policy. This factor alone provided adequate justification for an approach involving considerable technical risk and a large expenditure of funds.[11]

b(3
Do

[redacted] b(3) DOE

Meanwhile, design work was proceeding on the TX-14, with procurement for the program being authorized September 15, 1952.[15] Transportation of the heavy bomb from storage to airfield was a problem, since conventional equipment resulted in high wheel loadings that might damage roads and runways, and a multiwheeled, low-bed semitrailer with pneumatic tires was developed.[16]

[redacted] b(3) DOE

Sandia assumed the task of assuring weapon compatibility with carrying aircraft. The only bombers capable of delivering the TX-14 were the B-36 and the B-47. Fin clearance in the bomb bay was found to be ample in the B-36, but critical in the B-47. Every theoretical study indicated that both aircraft could not escape from the detonation effects of free-fall thermonuclear weapons, and it was decided that a parachute would be provided to slow the rate of fall of the bomb.

Ribbon parachutes were developed by Wright Air Development Center and tested, starting in late 1952.[18] Most of these drops were made at Edwards Air Force Base, California, with a few being conducted at the Salton Sea Test Base. Development contracts were issued for parachutes with a diameter of 100 feet. Subsequent computed down-times for this design were so great that the diameter was reduced to 80 feet.

This design was later changed to a 64-foot-diameter parachute that could be reefed for different bomb weights. [redacted] b(Dc

The system that finally evolved consisted of a pilot chute, a secondary extraction chute, and a main ribbon chute, all fitted into the afterbody of the bomb. Upon

release, the pilot chute, which was attached by a static line to the aircraft, deployed. This pulled out the secondary chute which, in turn, deployed the ribbon chute. The ribbon chute was reefed to a small diameter for 10 seconds and then opened to full size. Without this controlled deployment, the parachute would have jolted the bomb or would have been ripped away.

Tests were made with both B-36 and B-47 aircraft, and the drops continued until March 1954, when 49 releases had been made.

b(3)
DOE

b(1)
DoD

b(3)
DoE

Much of the work on the TX-14 had been performed up to this point, under the cognizance of Los Alamos. Santa Fe Operations Office suggested, July 14, 1953, that the same division of responsibilities on thermonuclear weapons be made as had been previously established for fission devices, and it was proposed that an interlaboratory committee, similar in scope to the TX-N Committee, be set up to work out the details of this division of responsibilities.[19] This committee, which was called TX-Theta, (the Greek letter theta stood for thermonuclear), was formed and held its first meeting October 26, 1953. Inasmuch as work on the TX-14 was well advanced, the attention of the Committee was directed largely toward other

thermonuclear weapons.[20] The work of the Committee assumed added importance from the start, as in the meantime the Soviet Union had announced August 12, 1953, that it had detonated a thermonuclear device.

Emergency-capability TX-14's first entered stockpile in February 1954. The bomb was 61.5 inches in diameter, 222 inches long, weighed about 29,500 pounds.

b(
DO

b(
Do

b(3)
DoE

b(3)
DOE

Meanwhile, other thermonuclear bomb designs had progressed to the point of stockpile entry. Since their yields, nuclear economics, assembly and logistics were better than those of the TX-14, the latter weapons were retired in October 1954.[21] Part of the retired material was used in the Mk 17/24 program.[22]

b(3
DO

Mk 15/29

[redacted]

The Military Liaison Committee wrote to the U. S. Atomic Energy Commission April 23, 1953, stating that the Department of Defense hoped to be able to deliver large-yield weapons by high-performance fighter-bombers and guided missiles. [redacted] A weapon proposal was requested by September 1953, with the prospect of stockpiling any selected designs by late 1955. The Division of Military Application forwarded this letter to Los Alamos, noting that a prelimin statement concerning the TX-15 might help to clarify this design, which appa ly had potentialities either as a tactical or strategic weapon, or both.[24]

b(
DO

[redacted]

b(
D

b(3)
DoE

b(3)
DoE

It was felt that this would have a diameter of 34.5 inches, a length of 145 inches, and a weight of 8000 pounds. The primary would be located aft of the secondary, provision would be made for parachute retardation, and a half-caliber flat nose would be used if this were proven ballistically acceptable.[20]

Field Command notified Sandia October 30, 1953, that early military authorization of the TX-15 program was expected. The bomb should be carried internally in the Air Force's B-36, B-47, B-52 and B-66; and in the Navy's AJ-1, AJ-2 and A3D-1. The B-47 would be the most restrictive aircraft as far as length and fin dimensions were concerned. The bomb should be capable of either free fall or parachute-retarded drop, and investigation should be made of the design of a bluff shape to optimize drag.[29]

b(3) DoE

A set of proposed military characteristics was released by Field Command November 13, 1953. Inasmuch as some thought had been given to the possibility of making the TX-15 compatible with the Air Force's long-range strategic missiles, such as REDSTONE and SNARK, both a TX-15 Bomb and an XW-15 Warhead were prescribed. Limiting parameters included a diameter of 35 inches, a length of 120 inches, and a weight of 6500 pounds.

The weapon would be required to withstand an altitude of 60,000 feet, temperatures from -65°F to +165°F, and an acceleration of ±10 gravities along the longitudinal axis. Automatic insertion and retraction of the primary capsule within a time cycle of 10 seconds would be possible at any time prior to release of the bomb, and during the missile trajectory except during high acceleration at launch or boost.

The TX-15 should be able to resist, without damage, any forces created by catapulted takeoffs, arrested landings, or normal flight maneuvers. The bomb would be capable of being dropped free fall and, if a high drag shape was provided, consideration was to be given to the deletion of the drogue parachute.

b(3) DoE

The ballistic properties of the bomb should be such that either free-fall or retarded trajectories would be predictable and reproducible. Releases were to be possible at all altitudes up to 60,000 feet and aircraft speeds of Mach 0.95. It

was hoped that the power supply would have a storage life of at least 2 (and preferably 5) years, and require no preparation other than installation in the TX-15, if permanent storage in the weapon were not possible.[31]

Sandia reported to the November 20, 1953 meeting of the TX-Theta Committee that a hemispherical nose appeared to be the most stable in wind-tunnel tests. This change was accordingly made to the shape of the TX-15.[32] [redacted]

b(3) DOE

Since a high-drag shape could not be provided without unduly increasing the weapon diameter, this would not be developed. [redacted] No attempts would be made to test releases at 60,000-foot altitudes and speeds of Mach 0.95 until aircraft with this capability became available.[33]

b(3) DOE

The TX-Theta Committee issued a formal report on the TX-15 January 4, 1954. [redacted]

b(3) DOE

The bomb would be designed for internal carriage and with an option of retarded delivery. A barometric fuzing system would be provided, having a continuous height-of-burst adjustment and a radar-type proximity fuze for the near-surface burst. An automatic inflight insertion mechanism would be incorporated. The

b(3)
DoE

The possibility of TX-15 missile compatibility was raised again in the March 26, 1954 meeting of the TX-Theta Committee. The SNARK was to be operational in early 1958, but could only carry a warhead weighing up to 7000 pounds. The G-26 NAVAHO would be available in late 1957 and could carry only 4000 pounds, but a G-38 follow-on NAVAHO, operational in 1960, would be able to carry 7800-pound warheads. The REDSTONE, which would be available in late 1957, could carry a warhead of 6900 pounds and, by sacrificing some range, a warhead of 7800 pounds. Since all these applications were some time in the future, the Committee decided that emphasis would continue on the bomb program.[35]

[redacted]

b(3) DOE

Report SC3390(Tr), Proposed Ordnance Characteristics for the TX-15 Weapon, was discussed at the June 30, 1954 meeting of the Special Weapons Development Board. [redacted]

b(3) DOE

The TX-15 was 34-1/2 inches in diameter, 130 inches long, and weighed 7500 pounds. [redacted]

b(3) DOE

Pullout switches closed at release of the bomb from the aircraft, and battery power started operation of the inverters. After the safe-separation interval timer completed its cycle, the X-unit could be charged by closure of the arming baro. When the detonation altitude was reached, the firing baro closed, connecting the output of the X-unit to the detonators. [redacted]

b(3)
DoE

The weapon would be stored in a completely assembled condition, less power supply and primary capsule. [redacted] Since the program was urgent, and since any prospective missile carriers were still far in the future, the TX-15 was restricted to bomb application.[38] Field Command suggested that the weapon case be sealed, to provide protection against its environment, and Sandia provided internal seals for all case joints. The afterbody protected the fuzing and firing components.[39]

b(3)
DoE

The Mk 15 Mod 0 Bomb was design-released in October 1954. Four major changes had been made since the Proposed Ordnance Characteristics had been issued. One was [redacted]

b(3)
DoE

b(3)
DOE

[redacted] Radar antennas were installed in the bomb fins, where they gave good coverage, not only straight ahead of the bomb but to the side. This caused detonation if the Mk 15 dropped close to the side of a building.[40]

Subsequent component testing for temperature, humidity, pressure, vibration, shock, dust and salt spray showed that all components, with some few exceptions, could satisfactorily withstand these environments. In the few exceptions, it was decided that the item would never experience the condition prescribed. Environmental tests were performed on six complete weapons, and included cycles of artic, desert and tropical conditions. These tests were successfully passed, as were various dynamic tests. Flyaround tests were conducted in a B-47, to detect any adverse vibrational frequency ranges, and the weapon was catapulted in ~~a B-52~~ an AJ. Drop-tower tests simulated the maximum loads on the bomb caused by carriage in various aircraft. The weapon was dropped from a height of 20 inches onto a concrete platform, propelled down a ramp and into a wall, and subjected to standard railway humping tests. The full-scale drop program included 11 ballistic and 22 fuzing and firing drops. To create extreme release conditions, two drops were accelerated by jato boosters.

Consideration again turned to the problem of developing a missile warhead, and a thorough discussion was held in a joint meeting of the TX-Theta and TX-N Committees on January 6, 1955. The design was still too heavy, but it was felt that perhaps 800 pounds might be shaved off the weight by reducing the thickness of the aluminum case.[41]

Some attention was given to carriage of the XW-15 on the F-101 aircraft. The project would have required a streamlined shape for external carriage known as Shape 96.[42] However, the program was later canceled.

Meetings had meanwhile been held at Redstone Arsenal to discuss installation of a warhead in the REDSTONE missile. [redacted]

b(3)
DOE

[redacted] b(3) DOE

[redacted][44] The missiles were the Army's REDSTONE and the Air Force's SNARK and NAVAHO.[45,46]

Development requirements for the installation of a Mk 15 Warhead in the Pod of the B-58 or Hustler airplane were established and, during 1955, the program was alternately canceled and revived.[47] By the end of the year, however, it had been decided to delete all applications of the Mk 15 Warhead, and to use the Mk 39 weapon.[48]

Meanwhile, work had been proceeding on the development of true contact fuzing for the Mk 15 Bomb, with several possible methods being studied. The use of probes, both fixed and extendible, was discarded, as it was found that too much of the weapon area was left insensitive to impact. A design using a double shell, having laminated layers of insulator and contact material which would crush on contact, was found to be overly sensitive to antiaircraft fire. A low-burst proximity fuze, operating in the range of 1 to 25 feet above the target, appeared feasible, but would require a long development period. The most practical method appeared to be the use of barium titanate crystals which, under pressure, produced a pulse of energy. Development of this device resulted in good reliability and high performance. Thermal-cell batteries would replace the nickel-cadmium units, and required no preparation or maintenance.[49]

A proposal was made that this new fuze be applied to Mk 15 weapons that would have only a bomb capability (at that time, the warhead application was still being considered).[50] [redacted] b(3) DOE Requirements for these programs had been generated by a letter from the Secretary for Defense dated May 3, 1955.

The Military Liaison Committee had meanwhile become concerned that a lightweight bomb would require quite different handling equipment than that provided for the Mk 15 Mod 0, and suggested that new nomenclature be assigned.[47] Thus, on December 2, 1955, the Division of Military Application redesignated the Mk 15 modification program of weight reduction, contact fuzing, and thermal battery, as the TX-29. The Mk 15 modification of contact fuzing and thermal battery alone would be the Mk 15 Mod 1 Bomb.[54] This latter program was later canceled when it was found that the production complex could not deliver enough critical components to support all the using programs.

[redacted] b(3) DoE

A trajectory arm switch was added to the fuzing system to prevent power from reaching the X-unit until the bomb had experienced a normal release.[55] These changes were incorporated in the Mk 15 Mod 2 Bomb which entered stockpile in March 1957.

TX-29

[redacted] b(3) DoE

Early in 1954, a feasibility study of the warhead was authorized for use with the NAVAHO, a supersonic, surface-to-surface, pilotless bomber (as the missiles were called in those days), capable of striking targets at ranges up to 3500 nautical miles.[56]

Initial studies showed that it would be difficult to provide a warhead with the desired weight, and the program was temporarily set aside pending receipt of results from Operation Teapot.[57] Subsequently, the Division of Military Application notified the Military Liaison Committee March 16, 1955, that it appeared better to proceed with modifications to the Mk 15 program, which would provide a lighter case and a contact fuze, than to continue with work on the TX-29.[58]

It was pointed out that a completely new design, such as the TX-29, might provide a slightly increased yield over the Mk 15 design. [redacted] The program was subsequently canceled by the Division of Military Application August 25, 1955.[52]

b(3) DoE

TX-16

[redacted]

b(3) DoE

[redacted]

b(3) DoE

4

A TX-16 Panel was named in mid-January 1953 to study the weapon logistics, with members from Los Alamos, the Air Force Special Weapons Center and Sandia.[59] The Air Force was assigned the task of providing a suitable carrier and handling equipment, no small task for a weapon of this size and weight.[60] [redacted] Sandia started to design a contact fuze, which was hoped to be ready for incorporation in the early weapons.[61] [redacted]

b(3) DoE

b(3) DoE

[redacted] b(3) DoE

Los Alamos would handle the detailed planning and coordination for the over-all project. Sandia would design and supply the afterbody, fuze, parachute, power supply and various test devices to be used during assembly and flight. The weapon would be baro-fuzed and baro-fired, using standard components. Carriers would be the B-36 and the B-47 aircraft.

Wind-tunnel studies were completed by October 1953, which determined the size of the fins and the height of the spoiler bands. A time of fall of about 200 seconds was desired, which required the use of a parachute.[62] The initial drop test was made December 7, 1953. Release was made at the Salton Sea Test Base from a B-36 at 39,500-foot altitude and 300-knot airspeed. This was a free-fall drop of about 52 seconds. The bomb started to pitch after release, but this motion soon damped out. Rockets were then fired to create both pitch and yaw oscillations, but these also damped out during the trajectory.[63] Subsequent tests were made, with and without parachutes, at both Edwards Air Force Base and the Salton Sea Test Base. The tests ended April 13, 1954, and good ballistic results were obtained.[64]

Los Alamos requested an evaluation of the weapon afterbody under conditions of 40-percent overload at the time of parachute opening. Sandia calculated that an 80-foot-diameter parachute would result in an opening shock of 7 g's.[65] Subsequent static testing showed that the afterbody would absorb this overload shock with a 1.22 factor of safety.

Sandia released its part of the TX-16 design April 15, 1954, with provisions for air burst only. It was hoped to later introduce the proximity fuze that had been developed for the TX-15, on a time scale that would not interfere with the TX-15 program.

[redacted] b(3) DoE

b(3) DOE

b(3) DOE

Mk 17/24

b(3) DOE

Subsequently, more confidence was developed in this design, and it was assigned a nomenclature of TX-17.[67] Sandia would be responsible for the design and production of the afterbody, fuze power supply, parachute and pertinent test and handling equipment. The TX-14 baro fuze would be used in the early weapons but be replaced by a proximity fuze as soon as possible.[68]

b(3) DOE

[redacted] 72

b(3)
DoE

By using components and designs from other weapons, emergency-capability TX-17 and TX-24 Bombs were hand-produced by Sandia and stockpiled May 1954. The fuze from the now-discontinued TX-14 Bomb was used, although work was in progress on a proximity fuze.[73]

The problem of handling a bomb that weighed slightly over 20 tons required considerable thought. Plans had been made to store up to nine bombs in each storage igloo, and this meant that the bombs would have to be moved to one side or the other of the igloo entrance so that three lines of the bombs could be established. In one proposed design, the bomb would be wheeled into the igloo on tracks running the length of the igloo. For transverse movement, the bomb would be jacked up and then lowered onto temporary tracks laid at right angles.

Sandia designed a system consisting of four strongbacks, each having a pair of 8-inch-diameter wheels and 6-inch-wide tires, connected together longitudinally.

The dolly could be moved into position by using a jackscrew to adjust the wheels to the proper angle, and a few men could easily push the bomb to the desired position.[74]

Drop tests of the parachute for the TX-17 started November 2, 1954 and continued until late 1955. Most of these drops were made from B-36 airplanes at Edwards Air Force Base, with some being made at the Yucca Lake Range and the Salton Sea Test Base. Initially, it was felt desirable to provide a large escape distance.[75] [redacted] A 64-foot-diameter chute could be reefed to provide a 100-second time of fall, but became unstable when reefed to produce a 75-second descent. Eventually, the system was designed to contain a 5-foot guide surface chute, a 16-foot deployment chute, and a 64-foot main canopy, all released in stages.[76]

b(3) DoE

[redacted]

b(3) DoE

By November 1954, all emergency-capability units had been modernized to Mk 17/24 Mod 0 status. The design did not differ in any important aspects from the TX-17, but the components were of certified stockpile quality. The Mk 17/24 Mod 0 Bombs thus became the first thermonuclear weapons to be stockpiled as a result of a regular production program.

The weapon could be carried and dropped by a B-36, if the release was made at an altitude of 40,000 feet or higher. Lower altitude releases, into denser air, would produce high-shock loadings. The B-52 could not be used as a carrier due to its high speed, which also created high shock loadings at release.[78]

It was noted in the May 21, 1954 meeting of the TX-Theta Committee that heavy production rates had been authorized for Mk 17/24 Bombs in late 1954, and it was suggested that as many improvements as possible be incorporated prior to that date. [redacted]

b(3)
DoE

A Mk 7-type automatic inflight insertion mechanism was to be used, and this redesign required some lengthening of the bomb nose. Sandia ran a wind-tunnel check, which showed that little effect on weapon stability resulted. The Mod 0 of the Mk 17/24 was not exactly a model of aerodynamic stability, as it oscillated with an amplitude of about 10 degrees during its fall, even with parachute retardation, but the nose, which was 2 inches longer, did not aggravate this effect. [redacted] Additionally, the tail fin of the TX-15 was changed at this time from an all-metal design to one of composite metal and plastic, and this change was also made in the Mk 17/24 Mod 1.

b(3)
DoE.

[redacted]

b(3)
DoE

[redacted]

b(3) DOE

Cables that connected components in the afterbody to the primary in the nose of the weapon were routed through a plastic conduit having pressure connections to maintain the warhead case seal. Other case ports and joints, which had been closed with tape in the Mod 0, were permanently sealed. A hatch door was provided in the nose and was of a sealed type that could be opened to install the capsule at the time the weapon was loaded on the strike aircraft.

[redacted]

b(3) DoE

The Mk 17/24 Mod 1 was design-released December 1954 and appeared in stockpile March 1955. By September 1955, all the Mod 0's in stockpile had been converted to the Mod 1 configuration.[22]

In the meantime, work had been proceeding on the design of a proximity fuze, but many difficulties had been encountered.[81] Additionally, the Military--and especially the Strategic Air Command--had developed increasing interest in true contact bursts, to be used for cratering enemy air fields. Sandia thus decided to design a true contact-burst fuze, and to apply this initially to the Mk 17/24 weapons. [redacted]

b(3) DoE

[redacted] The initial approach was to design a contact fuze that would operate against hard, flat targets, with the bomb striking in a nearly vertical position. Tests would then be made to discover how far the fuze could be extended for more severe impact conditions.[82]

It was relatively simple to design contact fuzes for fission weapons, since these devices were covered with a light ballistic fairing that was able to sense the shock of impact and signal detonation before any real physical damage was done to the weapon. However, in thermonuclear devices, the heavy case would have to sense the impending shock and detonate just before actual impact took place.

Discussions with Los Alamos led to the conclusion that the secondary reaction would occur if the primary reaction was completed, and it was decided to use a barium titanate crystal contact fuzing system developed for fission bombs.[83] Sandia performed some sled tests in Area III, from which a design was evolved using two networks each containing two impact crystals, mounted on the nose of the bomb. A fast-firing gap-type X-unit was concurrently developed.

Further work on parachutes was necessary, in order to produce a design which would permit releases from B-52 bombers and result in a down-time of 75 seconds. Sandia placed an order on Wright Air Development Center for both standard and heavy-duty parachutes with diameters of 40 feet. The first phase of this testing program was completed January 19, 1955, after eight drops had been made with standard chutes. Test results showed that opening shocks were lower than expected. However, the requirement for carriage in the B-52 was canceled April 24, 1956, due to release troubles in which the suspension sling failed to retract properly. Subsequently, the Strategic Air Command decided to use a 64-foot-diameter chute and to place an operational restriction of 365 knots airspeed and 20,000-foot altitude on the weapon at release.

The Mk 17/24 Mod 2 Bomb was design-released June 1, 1955. The weapon contained a Mk 17 Mod 0 Fuze, with both contact- and air-burst capabilities. The bomb was 61.4 inches in diameter, 298 inches long, and weighed 42,000 pounds. [redacted] The weapon could be stored for 18 months under stockpile storage

b(3)
DoE

conditions, and for 15 days as a ready weapon. Efforts were under way to increase the latter figure to 30 days, to meet the desired ilitary characteristics. A 6-month capability was desired for the fuze, normally stored in its own sealed container, and the attainment of this goal appeared hopeful.

Prior to dropping the weapon from the bomber, a safing switch was closed. Release of the weapon resulted in closure of the pullout switches, and weapon power was applied to the electrical system of the bomb. Parachute deployment was now initiated, if this option had been selected. At the selected arming altitude, an arming baro closed and started the charging of the X-unit. At the selected height for air-burst operation, the firing baro closed and detonated the bomb by firing the trigger circuit. The contact fuze acted as backup in the event of air-burst fuze failure, or it could be selected as the fuzing option. [redacted] b(3) DoE.

About 25 percent of the Mk 17 stockpile was converted to the Mod 2 configuration. The work was performed at sites by the Military under Sandia supervision during the period June to August 1956. The program which would have resulted in the Mk 24 Mod 2 was canceled, and by October 1956 all Mk 24's had been retired in favor of the Mk 36 design.[22]

The Mk 17 Mod 1 weapons were retired between November 1956 and August 1957. The Mk 17 Mod 2's were retired between August and October 1957, since Mk 36 weapons were then entering the stockpile in large enough quantities to fully support military plans for weapons of this yield range. The Mk 36 provided a higher yield than the Mk 17 and at a much lesser weight.

Glossary of Terms

Adaption Kit -- Those items peculiar to a warhead installation less the warhead; namely, the arming and fuzing systems, power supply, and all hardware, adapters, etc., required by a particular installation.

Air Force Special Weapons Center -- That element of the Air Force Systems Command having to do with compatibility testing of nuclear devices with aircraft. Located at Kirtland Air Force Base, Albuquerque, New Mexico.

[redacted]

b(3)
DoE

Committee on Atomic Energy -- Established by the Joint Research and Development Board (which see) December 1946. Was assigned task of coordinating research and development work on military weapons and equipment.

Contact Fuze -- A fuze that detonates the weapon by contact with the ground or target.

Cryogenics -- The science of refrigeration, especially with reference to methods for producing very low temperatures.

Cyclotron -- A device for imparting high speeds to electrified particles by electromagnetic and electrostatic means, used for bombarding atomic nuclei to produce transmutations and artificial radioactivity.

Department of Defense -- The Armed Forces; i.e., the Army, Navy and Air Force.

Detonators -- Explosive devices which when initiated by the x-unit ignite the lenses charges of the high explosive sphere. ~~Devices containing bridge wires which, when subjected to an electrical current, burn rapidly and act as a match to apply a flame to various points on the~~ outer surface of the high-explosive sphere.

Deuterium -- The hydrogen isotope of mass number 2.

Division of Military Application -- An AEC office that functions as liaison between the Military and weapons designers and producers.

Drag -- Resistance created by the passage of a body through the air.

Drogue Chute -- A parachute that slows the rate of fall of a bomb.

Drone -- A remotely controlled, pilotless aircraft.

Emergency Capability Program -- A weapons program to provide models of a given design in advance of regular production.

DOE b(3)

Field Command -- The local office of the Armed Forces Special Weapons Project, located on Sandia Base, Albuquerque, New Mexico.

Fuze -- A combination of the arming and firing devices of a weapon.

Greenhouse -- A full-scale test series held at the Pacific Proving Grounds. Series of four tests, starting April 8 and ending May 25, 1951.

b(3)
DOE

b(3)
DOE

Jato -- Named for Jet-Assisted Take-Off. A jet device initially designed to assist heavily loaded aircraft to take off from short runways. Used as a boosting device in missile launching.

Joint Chiefs of Staff -- ~~An~~ A group composed of the Chiefs of Staff of the Army, Navy and Air Force ~~group~~ to determine policy and to develop joint strategic objectives of the Armed Forces.

Joint Research and Development Board -- A Board established in mid-1946 as a postwar replacement for the Office of Scientific Research and Development. Its purpose was to suggest lines of research and development on military weapons and equipment.

b(3)
-DOE

<u>Los Alamos Scientific Laboratory</u> -- A laboratory established as part of the Manhattan Engineer District during World War II to devise a practical piece of atomic ordnance. Located at Los Alamos, New Mexico.

<u>Mach</u> -- A measure of speed. Mach 1.0 is the speed of sound, or 738 miles per hour at sea level.

<u>Manhattan Engineer District</u> -- A District of the Army Engineers established in August 1942 to provide the facilities needed for design and construction of the atomic bomb.

<u>Megaton</u> -- A measure of yield of a large weapon. One megaton is the equivalent of 1,000,000 tons of high explosive.

<u>Microsecond</u> -- One millionth of a second.

<u>Military Characteristics</u> -- The attributes of a weapon that are desired by the Military.

<u>Military Liaison Committee</u> -- A Department of Defense committee established by the Atomic Energy Act to advise and consult with the AEC on all matters relating to military applications of atomic energy.

<u>NAVAHO</u> -- A supersonic long-range missile developed for the Air Force by North American Aviation, Inc.

<u>Neutron</u> -- An uncharged particle of slightly greater mass than the proton.

Nontritiated -- Containing no tritium.

Nucleus -- The central part of an atom, containing most of its mass, and having a positive charge equal to the atomic number of the element.

Oak Ridge -- An AEC production facility located at Oak Ridge, Tennessee.

Office of Scientific Research and Development -- Established to serve as a center for mobilizing the scientific resources of the United States in World War II.

Operation Castle -- See Castle.

Operation Greenhouse -- See Greenhouse.

Operation Ivy -- See Ivy.

Operation Snapper -- See Snapper.

Operation Teapot -- See Teapot.

Operation Upshot-Knothole -- See Upshot-Knothole.

Pitch -- Motion of the bomb as it falls through the air, such that the nose and tail alternately rise and fall.

Primary -- A fission bomb that acts as the source of energy to start the secondary or thermonuclear reaction of a two-stage device.

Proton -- The nucleus of the atom of the light isotope of hydrogen. It has a unit positive charge of electricity.

Prototype -- An early weapon type, generally hand-produced before a production run.

Proximity Fuze -- A fuze that detonates the weapon as soon as it comes within a certain specified distance of the ground or target.

Pullout Switch -- A switch whose contacts are kept separated by insertion of some nonconducting material. Release of the bomb from an aircraft results in closure of the switch contacts.

[redacted]

Radar -- Named for Radio Detecting and Ranging. Radars emit a pulse of high-frequency energy and measure the time lapse from that transmission to receipt of a reflected electrical "echo" from an object. This time measurement determines the distance of the object from the transmitting antenna of the radar.

REDSTONE -- A supersonic long-range missile developed by the Army's Redstone Arsenal.

Redwing -- A full-scale nuclear series of 17 tests held at the Pacific Proving Grounds from May 4 to July 21, 1956.

Retarded Bomb -- A bomb provided with some means for slowing the rate of descent, generally a parachute.

Retrofit -- To modify a weapon, i.e., "retroactively outfit" it with changed material.

Ribbon Parachute -- A parachute having a set of ribbons in place of a solid canopy. This type of parachute provides less severe deceleration on deployment.

6(3) DOE

b(5) DOE

Teapot -- A less-than-full-scale test series held at the Nevada Test Site. Series of 14 tests, starting February 18 and ending May 15, 1955.

Thermal Battery -- A battery whose electrolyte is in a solid state while inactive. To activate, heat is applied to this electrolyte, melting it and putting the battery into active output condition.

Thermonuclear -- Two-stage reaction, with a fission device exploding and starting a fusion reaction in light elements.

Ton (Yield) -- A means of measuring the yield of an atomic bomb by comparing its output with the effect of an explosion of TNT. A 1-ton yield is equivalent to the detonation effect of 2000 pounds of high explosive.

Tritium -- The hydrogen isotope of mass number 3.

Two-Stage -- Combination of fission and fusion action in a weapon.

TX-N Committee -- A joint committee of Los Alamos Scientific Laboratory and Sandia members, established to guide the development of implosion-type weapons.

TX-Theta Committee -- A committee established to guide the development of thermo-nuclear weapons.

University of California Radiation Laboratory -- A laboratory established under the guidance of the University of California to work on thermonuclear designs, and located at Livermore, California. The laboratory was founded largely as the result of the interest of Dr. Edward Teller in pursuing thermonuclear work.

Upshot-Knothole -- Tests of atomic devices, held at the Nevada Test Site. Series of 11 shots, starting March 17 and ending June 4, 1953.

Uranium-235 -- A radioactive element, an isotope of uranium-238.

Uranium-238 -- A radioactive element, atomic number 92. Natural uranium contains about 99.3-percent of uranium-238; the rest is uranium-235.

Wooden Bomb -- A weapon designed to have an infinite shelf life and to require no special storage or surveillance. "As trouble-free as a block of pine."

X-Unit -- A device used to provide high voltage to the weapon detonators. ~~A high-voltage transformer~~.

Yaw -- Motion of the bomb as it falls through the air, such that it alternately veers left and right.

Yield -- The ~~A means of~~ measur~~ing~~e of the effect of a nuclear detonation ~~by~~ compar~~ing it~~ed to ~~with~~ the effect of an explosion of TNT. By definition one kiloton is 10^{12} calories.

Yucca Lake Range -- A test range located at Yucca Lake, Nevada.

References

1. SRD Report, RS LAMS-1450, Edward Teller to Distribution, dtd 8/28/52, subject, Lectures - 1951. SC Technical Library.

2. SRD Report, RS LA-1006, Los Alamos Scientific Laboratory to Distribution, dtd 12/23/46, subject, Relations Between the Various Activities of the Laboratory, by Samuel K. Allison. SC Technical Library.

3. Unclassified Book, The New World 1939/1946, Vol I of A History of the United States Atomic Energy Commission, dtd 1962, by Richard G. Hewlett and Oscar E. Anderson, Pennsylvania State University Press.

4. SRD Report, RS SWC-52-496, Air Force Special Weapons Center to Distribution, dtd 10/27/52, subject, Atomic Weapons Development. Historical Division Files, Kirtland Air Force Base.

5. TSRD Report, RS XXVIII-1418, Los Alamos Scientific Laboratory to Distribution, dtd 3/1/53, subject, LAMS-1520, Lectures 1953 on Thermonuclear Weapons. SC Files.

6. TSRD Report, United States Air Force to Distribution, dtd 1953, subject, A History of the Air Force Atomic Energy Program, 1943-1953. Historical Division Files, Kirtland Air Force Base.

7. TSRD Report, RS SWC-55-TS-076/3, Air Force Special Weapons Center to Distribution, dtd 2/14/55, subject, The Thermonuclear Weapons Program at the Air Force Special Weapons Center, July 1952 to July 1954. Historical Division Files, Kirtland Air Force Base.

8. TSRD Report, RS OA-XLIII-3293, Defense Atomic Support Agency to Distribution, dtd 8/15/62, subject, DASA-1220, Nuclear Test Summary, Trinity to Hardtack. SC Files.

9. SRD Ltr, Los Alamos Scientific Laboratory to Wright Air Development Center, dtd 10/3/51. SC Central Technical Files, W-7, Alpha.

10. SRD Ltr, RS 1/292, Los Alamos Scientific Laboratory and Sandia Corporation to Division of Military Application, dtd 5/22/52. SC Archives, TX-14, 1952-4.

11. SRD Ltr, RS 3427/47250, Military Liaison Committee to U. S. Atomic Energy Commission, dtd 6/13/52. SC Archives, TX-14, 1952-4.

12. SRD Ltr, U. S. Atomic Energy Commission to Military Liaison Committee, dtd 6/23/52. AEC Files, Organization and Management - 12, 7/51-6/52.

13. TSRD Report, RS SWC-59-TS-040, Air Force Special Weapons Center to Distribution, dtd 3/1/59, subject, Nuclear Weapon Developments. Historical Division Files, Kirtland Air Force Base.

14. SRD Ltr, RS 1240/1211, E. H. Draper, SC, to R. W. Henderson, SC, dtd 8/16/52, subject, TX-14 Discussions at Los Alamos Scientific Laboratory. SC Archives, TX-14, 1-, 1952-4.

15. SRD Ltr, RS 3466/67336, Santa Fe Operations Office to Los Alamos Scientific Laboratory, Sandia Field Office, and Sandia Corporation, dtd 9/15/52, subject, TX-14. SC Archives, TX-14, 1952-4.

16. SRD Ltr, RS 1/370, Sandia Corporation to Air Force Special Weapons Center, dtd 10/2/52, subject, Assembly Facilities. SC Archives, TX-14, 1952-4.

17. SRD Report, RS 3466/38069, Sandia Corporation to Distribution, dtd 5/1/53, subject, SC2860(TR), Development Progress Report No. 3, Emergency Capability Thermonuclear Weapons. SC Reports Files.

18. SRD Ltr, RS 1200/690, Sandia Corporation to Air Force Special Weapons Center, dtd 12/11/52, subject, Development Drop Program, TX-14. SC Archives, TX-14, 3-, 1952-3.